J. Bangladesh Electron. 15 (1-2); 67-76, 2015

Design and Development of a Low Cost Intelligent Home Appliances Automation System

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Abstract

In this research work, a microcontroller based low cost, self controlled and intelligent home automation system was designed and developed. Among many, one of the advantages of the system was that it can minimize the effect of phantom loads power or wastage of energy. This innovative system can minimize or reduce the consumption of wastage power or phantom loads power by promoting user to switch off the device completely automatically. The system works by controlling other devices by the user demand which was written in the main controlling section. PIC16F84A microcontroller was used as the main controller as they provide open source and low costs solutions. To better lowering the device cost, the IR sensing module was used in the device is a typical 38 KHz module. No operating switch was required in the system and that was the most special features of the development system.

Keywords: Microcontroller, Home Appliance, Intelligent Automatic Control, Low Power Consumption, Phantom Power, Smart Home.

1. INTRODUCTION

Everyone imagine to have a life where everything will be on the finger tips or it will be more convenient if it happens automatically. To achieve this, more technological advancement in home automation is required. Smart Home System is used to control any devices in home or in office or in other places. It also can switch on or off for all devices. The goal of a smart home system is to control automatically a large number of electronic devices easily according to the optimum or usual demand of the user of the home as well. A simple smart home system usually turns on the kitchen lights and turn off the alarm when the garage door opener activates. Smart homes typically have many more complicated systems but they all operate via the same principles

From an engineering point of view, a home can be broken down into the “Six S’s” as specified by Brand [1] are Site, Structure, Skin, Services, Space Plan and Stuff along with who has access to each “S”. Home automation systems mainly deal with the last “S’s,” namely Service, Space Plan, and Stuff. A study [2] showed that in addition to home automation technology and devices, a modern home relies on three to seven services or companies to provide them with infrastructure support like Internet, telephone, electricity, gas, etc. Another study [3] done on different homes showed that people choose the “Site” of the home based on factors like the availability of uninterrupted power, high speed Internet, etc., excluding other factors like property prices and neighbors which are beyond the scope of this work.

The Home Automation Protocol (HAP) was developed in order to facilitate the master–slave communication in a home automation network [4]. This protocol ensures a prioritized, interlocked exchange of data. It also supports dynamic addition and removal of devices on the network. A user interface on the PC offers device registration, control as well as diagnostic utilities. Bluetooth development kit from Ericsson was used for the development [5]. A microcontroller was used as a device controller for client modules [6] [7].

An intelligent living-space [8] based on blue-tooth system was practically designed and implemented in a living room, which was supported by the Taiwan Education Ministry under "Projects of Improving Teaching Superiority Taiwan colleges", and the whole system was finally proved to be successful with its steady functions.

PC based automatic Smart Home system is a conventional concept today [9]. But it is very costly and takes time to implement. To offer low cost automatic control like PC based automation simple electronic automation can be done. Electronic automation system can handle limited devices depending on IC memory on the other hand PC based Smart Home system can handle many devices because it has a larger memory. But comparatively for the countries like Bangladesh it is very difficult to afford pc based smart home system .That's why cheap cost and simple electronic based smart home system will be able to play a vital role in this regard.

Smart home works depending on fairly simple systems like Programmable integrated circuit (PIC) and sensing transducer [10] [11]. Normal home devices such as lights, entertainment systems, heaters, air conditioners, computers, security systems operate depending on transmitter and receiver which is known as transducers commonly. This Programmable integrated circuit (PIC) detects a certain signal initiated by IR sensor which is usually from a remote control.

The main objective of the research was to design an automatic system to keep maintaining any electrical device in room within required range. The specific objectives of this work was 1) to design and develop a device that is able to control switches itself, 2) to design and develop a controller section by using microcontrollers and embedded system and 3) to implement communication very simply by using only IR module.

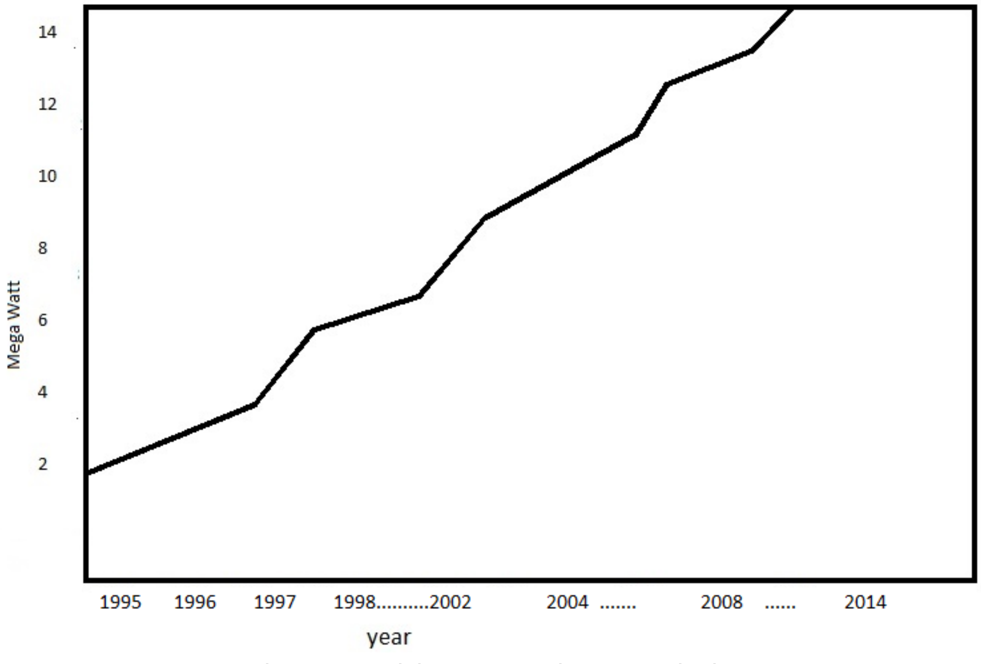

Fig. 1: Electricity wastage in Bangladesh

2. GENERAL OVERVIEW

This work keeps a specialty to save energy very efficiently. The theme is very simple i.e. after using an appliance the power will be turned off automatically and hence the power will be saved. It may result in increase of financial capital, human comfort and environmental value. In terms of human comfort, this system also can help the disabled people inside their own house. Usually, the plug point in a house is so high and people with wheelchair or paralyzed person cannot reach it. This is a problem for them especially if they want to turn off a plug or device like television, hand phone charger or other electrical equipment that is attached to the plug. So a solution is needed that can shut off or turn off these device automatically remotely as well as can conserve electrical energy if let the device turn on. Fig. 1 shows the electricity wastage in Bangladesh in 1990 to 2015.

This work was purposely done to minimize or reduce the consumption of the phantom loads of wasting energy by switch off the device completely. The phantom loads power refers to the electrical powers that are consumed by electronic appliances while they are in a standby mode. The example of the phantom appliances and its consumption can be seen in Table 1.

Table 1: Common Home Appliances Phantom Power

Products/Devices	Phantom Power(Watt)
Cable Modem	3.8 W
Satellite Box	15.7 W
Computer(Desktop)	2.8 w(Off)/21 W(Sleep)
CD Player	5.0 W

3. SYSTEM DESIGN

Basically the system was differentiated by three main sections such as sensing section or input section, main controller section and driver section which plays an important role to develop a better, compatible, user friendly and cost efficient smart home system than other existing system. In general, the system consists of two major parts that needs to be developed; hardware and software. For the hardware part it consists of system board which includes PIC16F84A, IR led, relays and some basic electronic components. In the system, PIC microcontroller plays the vital role.

Fig. 2 represents the overall design of the system. The main controller module (PIC 16F84A) was able to control the device module that already been attached to the appliances such as lamp, fan, television and others indicated by LED. Each device has directly connected with main controller. Fig. 3 represents the detailed view on how this system works.

3.1. Electronics Design

Electronics circuit is always important for designing a good and reliable product especially in embedded system related devices. For the current system, the electronic design is divided into three main parts: 1) User interface module 2) The main controller module and 3) the device application module.

The main controller module consists of user interface module and device application module. User interface module could realize the movement of human and make an electric signal and push it to the main controller module. Depending on this signal the main controller module takes the decision and the device application module will run according to this decision. For this purposes, the overall system module have components such as IR led, LM 358P, Relay, Transistor. Light Emitting Diode (LED) to indicate status of the devices and to OFF/ON the switches for users to turn ON or OFF the main controller device. Also the design of the casing should be safe for user and have to have a protection to the electronics parts inside it.

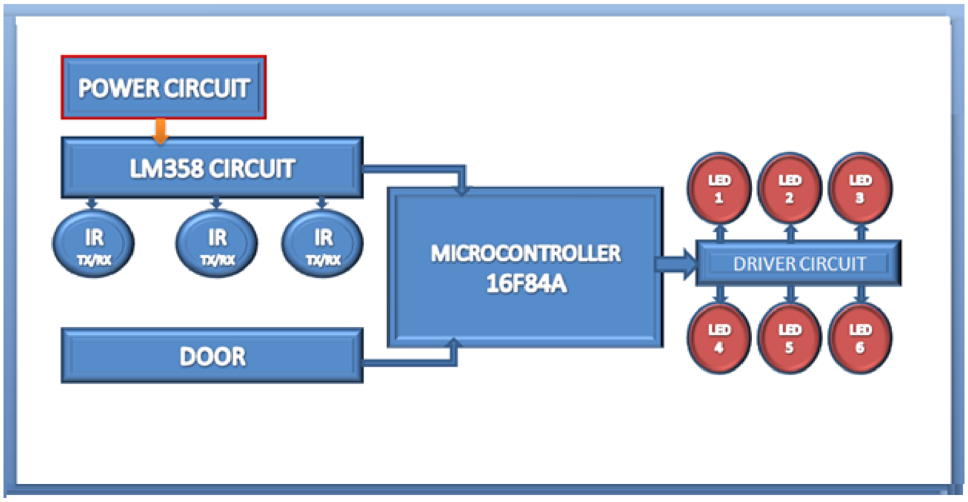

Fig. 2: Overall system design

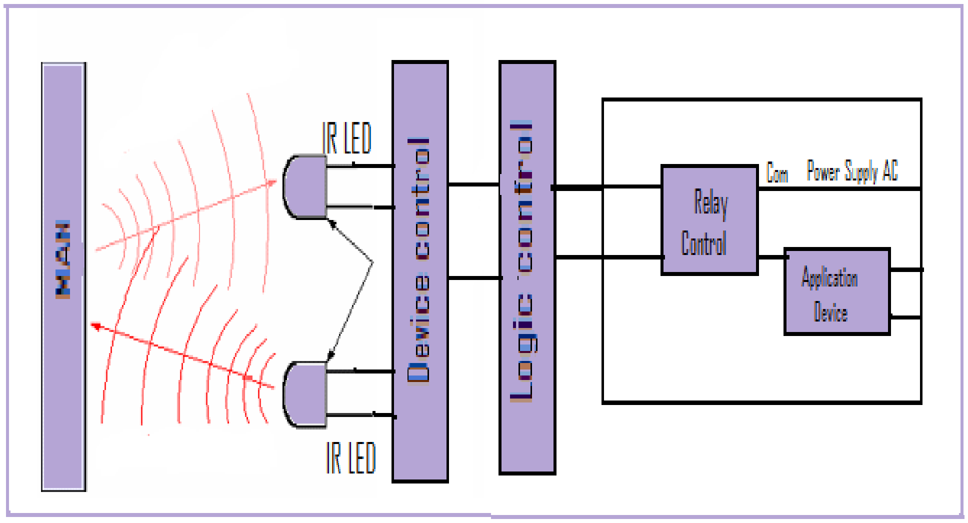

Fig. 3: Detailed view of the system

3.2. Hardware Design

This system was developed with the help of hardware and software. Actually it was a challenging job to well fit, adjust and to tune the hardware section. Initially different components were connected according to the circuit diagram on the breadboard when the circuit was in research table i.e. when it was being tested. After completing the testing on breadboard it was transferred to the Vero circuit board and was soldered very carefully with soldering iron. Fig 4 represents the total system construction in this regard.

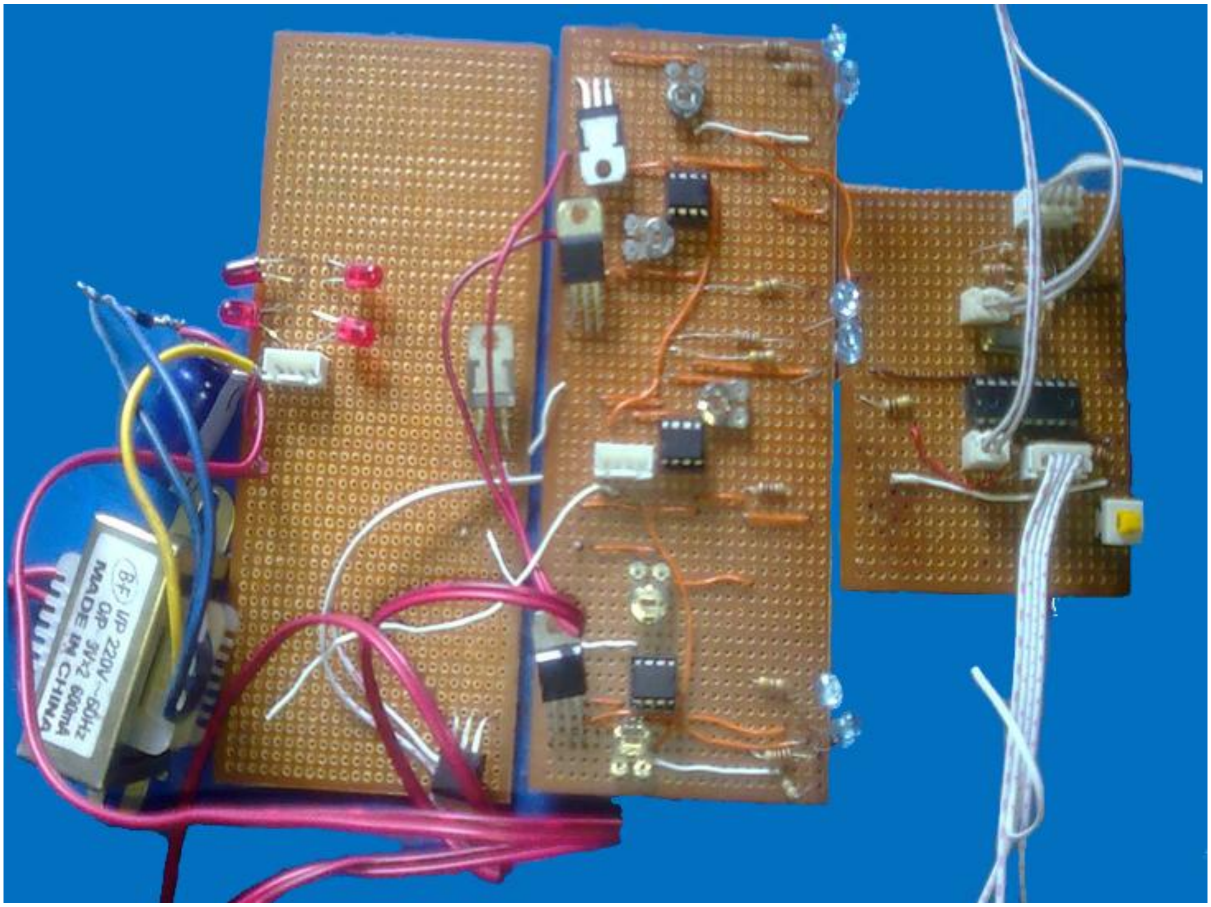

Fig. 4: The circuit on Vero board.

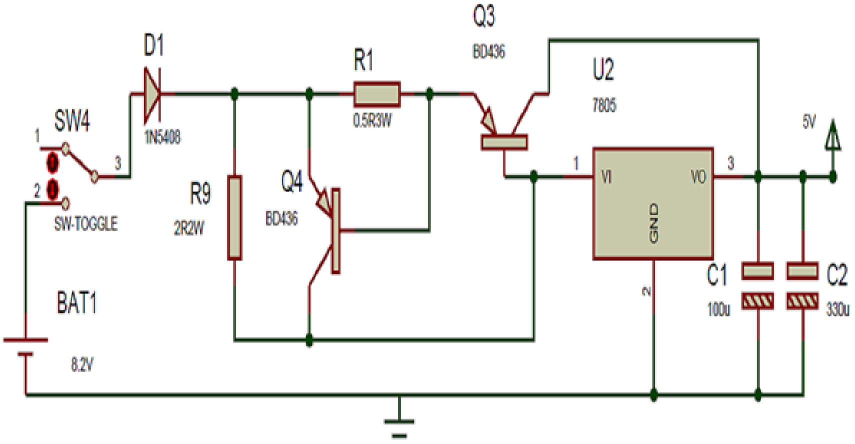

Fig. 5: Voltage regulator circuit for main control module.

3.3 Power Source

In the system, several specific voltages were needed to active the electronics components such as the microcontroller, the LCD display, the LEDs and the relays. All of these components required a certain level of voltages and certain devices that cannot tolerate the exceeded amount of voltage. To solve this problem, the voltage source must go through a voltage regulator circuit before being applied into the application circuit. For the developed system, both main controller module and device application module had a different voltage regulator. Fig. 5 represents the voltage regulator circuit for main control module based on LM 7805 voltage regulator IC. For the device application module, USB charger was used which has an output voltage around 5 to 5.5 V and was suitable for microcontroller voltage and electronics inside the device application module. Fig. 6 represents the block diagram of the device application module.

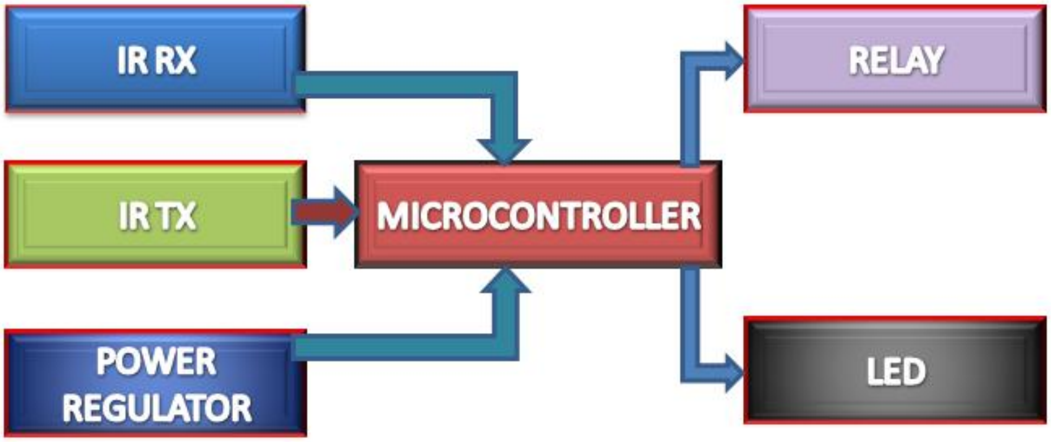

Fig. 6: Block Diagram of device Application Module Circuit

4. PROGRAM DEVELOPMENT FOR MICROCONTROLLER

In the developed system, PIC16F84A microcontroller was used as controller circuit. Windows C-compiler and IDE for Microchip microcontrollers from CCS (Custom Computer Services) was used. C level CCS's PCWH software was used as Debugger. Fig. 7 represents the flowchart of system program.

5. IR TRANSMITTER, IR RECEIVER AND COMPLETE CIRCUIT

The Fig. 8 represents the low range IR sensor i.e. IR transmitter and IR receiver circuit and Fig. 9 represents the complete circuit diagram of the system. At the first stage of this circuit the IR transmitter and receiver circuit sense the signal and send it to the input pin of the microcontroller (A_0, A_1 as shown in Fig. 9).The input section was formed with the help of LM 358P op-amp. This was used as a comparator that can compare the rays of IR and the output will be given as high or low and this output was send to the output pin of the microcontroller. Microcontroller section was formed with a 4MHZ crystal oscillator which was attached with 15 and 16 no. pin and pin no 4 was connected with 5V via a resistor. Pin no. 14 was connected with positive voltage supply and pin 5 was connected with ground. Depending upon the program code written in the microcontroller the circuit will make the proper decision and the signal was given to the output pin.

The driver section was formed with the help of transistor, resistor and relay. The connection was shown in Fig. 9 with the output pin of the microcontroller, there are some driver sections connected respectively. With this driver circuit the AC appliances was connected properly to perform the operation. To operate each section appropriately an individual time was allocated internally. When the IR section was activated with the movement of a human or any object then the corresponding circuit get ON and it remain according to the preset time. After finishing the time the circuit will turn off automatically. But if there is no one in the room then the IR section will never turn ON. For example if anybody rises from bed then with the movement of the man, the IR circuit which is set previously at a perfect position will turn ON and it will drive an AC appliance like a light or a fan etc. and it will remain ON during the entire time duration. Like this way every section of the circuit works.

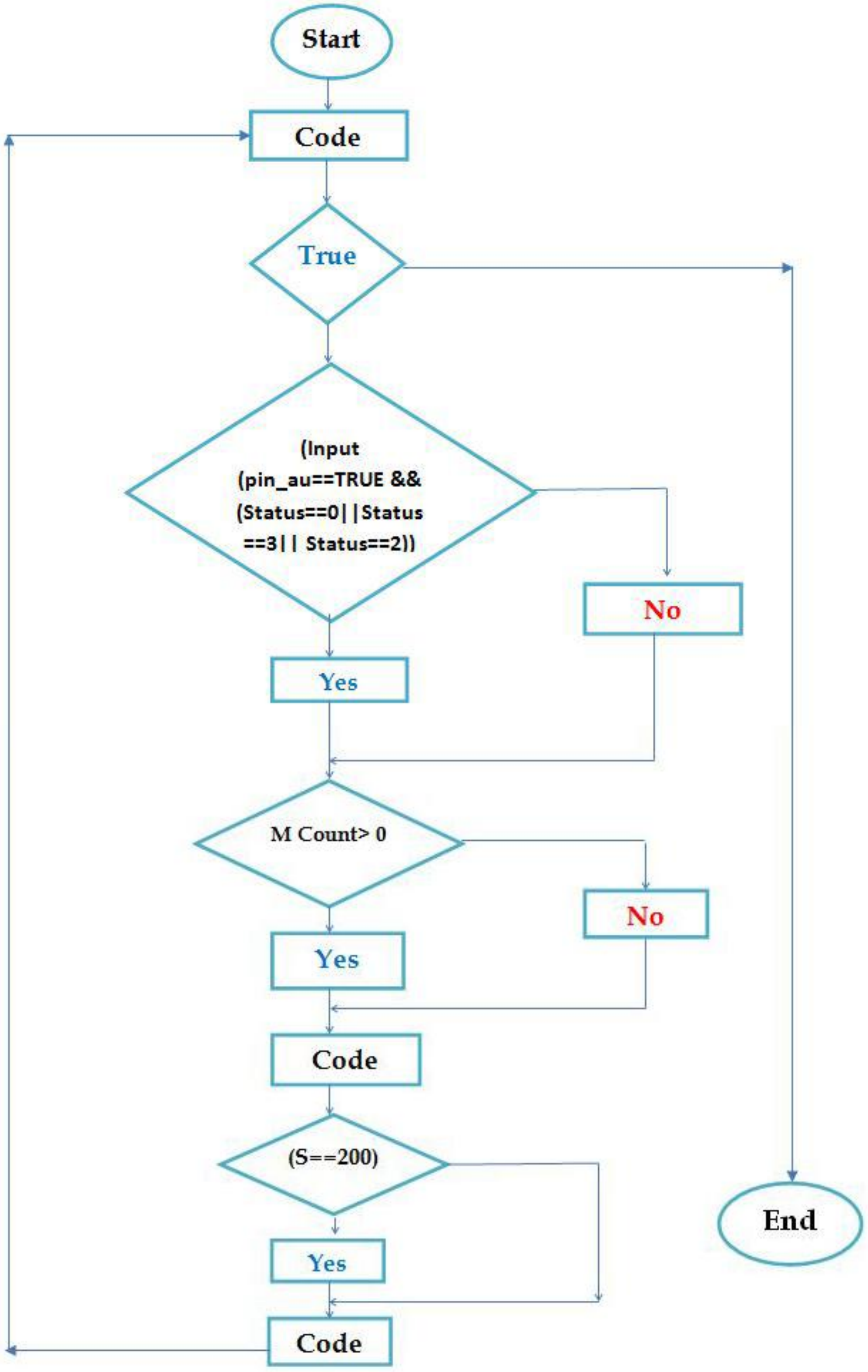
Start
Code
True
(Input (pin_au==TRUE && (Status==0||Status ==3|| Status==2))
No
Yes
M Count> 0
No
Yes
Code
(S==200)
Yes
Code
End

Fig. 7: Flowchart of the program.

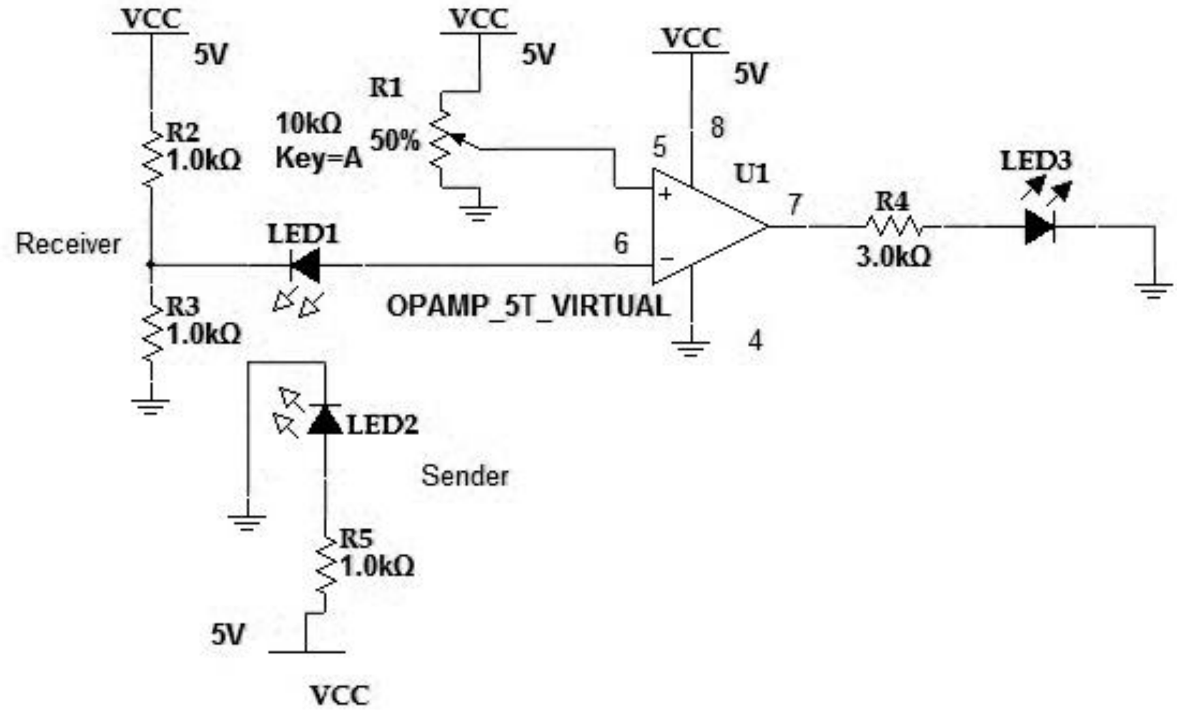

Fig. 8: Low range IR sensor

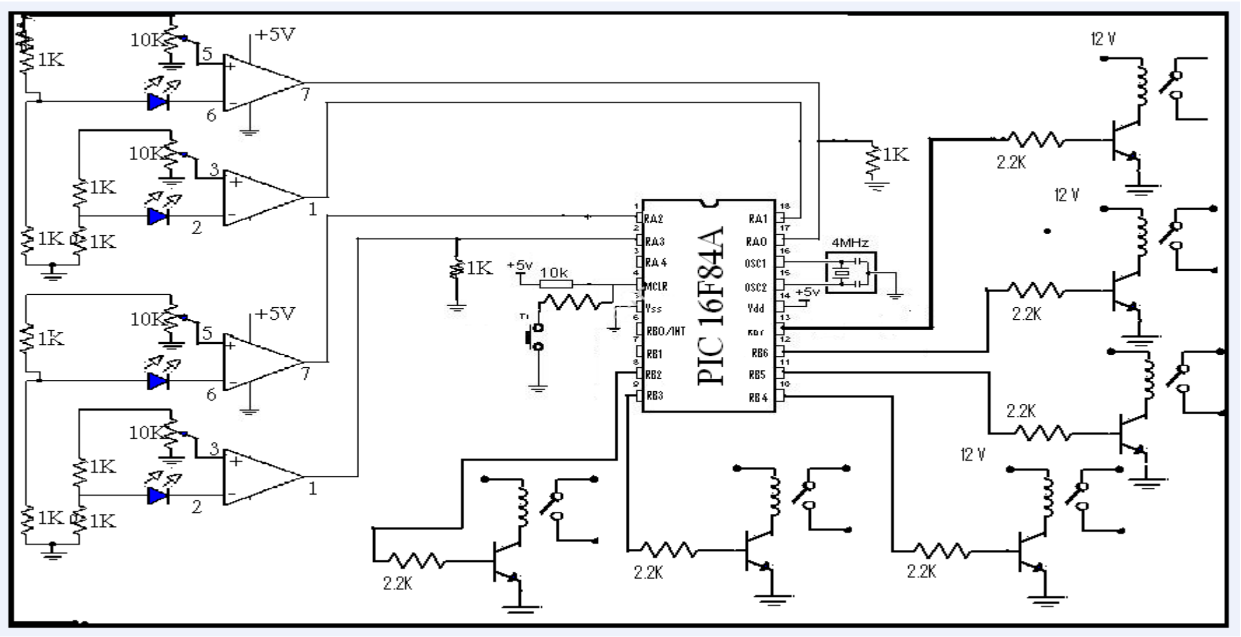

Fig. 9: Complete circuit diagram of the system

6. RESULTS AND DISCUSSION

The total system was tested under some environmental consequences and it operated successfully. Every section i.e. module performed its task successfully and that’s why the system works efficiently as discussed about its action. After testing rigorously, it was clear that the developed system achieved the objectives that could control a switch automatically;

however a few challenges have been countered while developing the system. The first challenge was to developing a stable connection regarding IR transmitter and receiver. Usage of IR was always check some and challenging task. Much more difficulty arises when came the range adjustment. After adjusting the range next challenge was to maintain the time interval in PIC microcontroller. It can be concluded that maybe the solder was too hot till the components have a slight defect or errors than others and it was not possible to detect which components have the error. For this problem, there were no permanent solutions other than to fabricate the circuit industrially but it will be costly and quick solution was to replace the components one by one until it could met the specifications needed to success the system.

The test has been done to make sure the success of the system. A summary have been made and placed below. From the calculation, the power consumption for device application module is 2.5 Watt. These can be calculated by using the equation 1 as below to calculate the power. The power consumption depends on the characteristic of the USB charger that will rate about 500mW with 5 Volt output.

$$P=V\times I \quad \ldots\ldots\ldots 1$$

$$P=5\times 0.5 \quad \ldots\ldots\ldots 2$$

$$P=2.5\ \text{Watt} \quad \ldots\ldots\ldots 3$$

7. CONCLUSION

The cost of the high sensitive developed system was low but it is better for power saving. For the energy conservation purposes, each device only consume maximum of 2.5W and the current supply to the device is only about 500mA. Although the systems have a little power consumption, but it was much lower than most of the phantom powers that being generate from household appliances. By applying the developed system to the household appliances, it was found that lower the phantom power being drawn from the supply by turning off the devices and hence the phantom power consumption is reduced. Several improvement and innovation can be added to the current system to enhance its functionality and marketability. In future by using radio frequency, image processing via pc media and ultrasonic sound sensor could make the current system more sensitive and secured.

ACKNOWLEDGEMENTS

The authors are thankful to Electronic Laboratory, Department of Applied Physics, Electronics & Communication Engineering, Islamic university, Bangladesh for extending experimental facilities.

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